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Subduction mega-earthquakes and other geohazards: IODP NanTroSEIZE as a type example for complex scientific drilling

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Subduction zones account for 90% of global seismic moment release, generating damaging earthquakes and tsunamis, with potentially disastrous effects on heavily populated coastal areas. Understanding the processes that govern the strength of earthquakes, and nature and distribution of slip along these plate boundary fault systems, are crucial steps toward evaluating and mitigating geohazards, including tsunamis. As a consequence, the foremost goal of the IODP project NanTroSEIZE is to understand the mechanics and dynamics of seismogenesis and rupture propagation along the active plate boundary faults of a subduction zone, in terms of direct in situ sampling and instrumentation at depth.

NanTroSEIZE is a multi-expedition, multi-platform complex drilling project which eventually will complete a transect of holes the deepest of which will penetrate the seismogenic zone off the Kii Peninsula, Japan, in ca. 6 km depth. Stage 1 drilling included three coordinated riserless expeditions with RV Chikyu to drill several sites across the continental slope and rise in fall 2007 through early 2008. The first of these was a logging while drilling (LWD) expedition that is serving as a geophysical baseline for all of the Stage 1A drilling sites (Expedition 314: LWD Transect). This was followed by a coring expedition (Expedition 315: Megasplay Riser Pilot) aimed at sampling the materials and characterising in situ conditions within the accretionary wedge to 1 km below seafloor at Site C0001 above the Stage 2 drill hole across the deep “mega-splay” out-of-sequence thrust. Expedition 316 (Shallow Megasplay and Frontal Thrusts) targeted another shallow fault zone of the “mega-splay” system in the older accretionary prism (Site C0004) as well as the frontal thrust at the toe of the young accretionary prism (Sites C0006 and C0007).

Initial results from Stage 1A drilling reveal new insights into the stress history and temporal evolution of the Nankai forearc. First, there is no discontinuity in the depositional record between thick forearc basin sediments and the underlying, late Miocene accreted strata (C0002). Second, both borehole breakouts (LWD results) and the orientation of structural measurements on cores suggest a pattern of compression parallel to plate convergence in the wedge, trench-parallel extension above the branches of the mega-splay fault (in particular Site C0001), overlain by trench-orthogonal normal faults in the forearc and below, suggesting predominantly extensional stresses in the overriding accretionary system. Third, the fault zones are highly active given immense problems in borehole stability and core recovery at Sites C0001, C0004, and C0006. The initial Stage 1A shipboard data serve to put forward preliminary hypothesis on the displacement history along the mega-splay and frontal thrust faults. Those data will soon be complemented by Stage 1B drilling into the incoming sedimentary sequence (exp 322) and Stage 2 borehole observatory preparation (exp 319) later in 2009.